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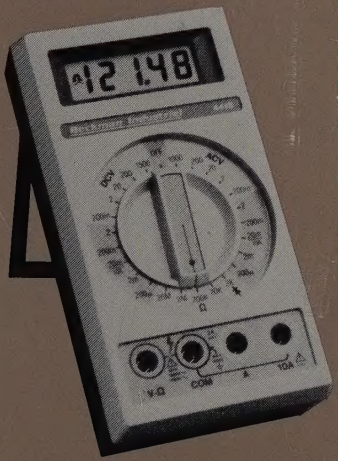

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MODELS 4410 AND HD140

Digital Multimeters Operator's Manual

CRT SERVICE SAFETY REMINDER

A POTENTIAL DANGER TO YOU AND YOUR METER EXISTS WHEN MEASURING VOLTAGES IN THE HORIZONTAL OUTPUT AND DAMPER STAGES OF CRT EQUIPMENT. THIS DANGER IS CAUSED BY THE HIGH VOLTAGE TRANSIENTS *(GREATER THAN 6000 VOLTS)* THAT OCCUR IN THESE CIRCUITS. PLEASE REFER TO YOUR CRT SERVICE MANUAL FOR PROPER SERVICING INSTRUCTIONS.

4410
SN# 5DB29163
2/10/86
ZELL

Instructions 3000-940-130-A

MODELS 4410 AND HD140 DIGITAL MULTIMETERS OPERATOR'S MANUAL

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February 1985 Printed in U.S.A.

WARRANTY

ONE-YEAR LIMITED WARRANTY

Models 4410 and HD140 Digital Multimeters are warranted in entirety against any defects of material or workmanship which develop for any reason whatsoever, except abuse, within a period of one (1) year following the date of purchase of the multimeter by the original purchaser. This warranty is extended by Beckman Industrial Corporation (manufacturer), only to the original purchaser or original user of the multimeter, who must, as a CONDITION PRECEDENT TO WARRANTY COVERAGE AND PERFORMANCE THEREUNDER BY MANUFACTURER, complete and return the Warranty Registration Card, received on purchase of the multimeter.

In the event a defect develops during the warranty period, manufacturer will, at manufacturer's election, repair or replace the multimeter with a new or reconditioned model of equivalent quality. In order to obtain performance of any obligation of manufacturer under the warranty, the original purchaser or original user must return the defective multimeter, postage prepaid, along with a handling charge of $3.00* to:

Instrumentation Products Division
Beckman Industrial Corporation
630 Puente Street
Brea, CA 92621
Attention: Customer Service

or to any other Authorized Service Center.

In the event of replacement with a new or reconditioned model, the replacement unit will continue the warranty period of the original multimeter. Replacement units will be returned by UPS, typically with only two (2) working days turnaround at the Service Center.

*Prices are subject to change without notice.

ANY IMPLIED WARRANTIES ARISING OUT OF THE SALE OF A MODEL 4410 or HD140 MULTIMETER, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE ABOVE-STATED ONE (1) YEAR PERIOD. MANUFACTURER SHALL NOT BE LIABLE FOR LOSS OF USE OF THE MULTIMETER OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, OR ECONOMIC LOSS, OR FOR ANY CLAIM OR CLAIMS FOR SUCH DAMAGE, EXPENSES, OR ECONOMIC LOSS.

Some states do not allow limitations on how long implied warranties last or the exclusion or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

BECKMAN INDUSTRIAL CORPORATION
Brea, California

Dear Customer:

Congratulations on the purchase of your new Digital Multimeter! Beckman Industrial Corp., a leading international manufacturer of electronic test instruments, process instruments, and precision components, has extended its knowledge and skills into the production of this series of 4½ Digit Multimeters. Because of the time and care taken in the design and manufacture of your multimeter, we are sure that you will enjoy the use of it for many years to come.

Beckman Industrial Corporation

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Section One
INTRODUCTION

Models 4410 and HD140 Digital Multimeters are completely portable, 4½-digit multimeters with liquid-crystal-display (LCD), designed for use by the person who demands a multimeter that is accurate, reliable and always ready for use. Equipped with five functions and 27 ranges, each test position on the multimeter is quickly and easily selected with a simple turn of the single selector switch. Small enough to fit in most attache cases and equipped with a multiposition tilt stand, these multimeters are equally suited for design engineering, production testing, field servicing, and industrial maintenance applications.

In addition to the features described above, these multimeters also offer three particularly useful digital multimeter features: Insta-Ohms® Quick Continuity Indicator, ten-ampere AC/DC current measurement capability, and the capability of measuring both AC voltage and current in true RMS. True RMS permits accurate measurement of even the nonsinusoidal waveforms typically found in switching power supplies, motor speed controllers, SCR regulators, and digital systems. The multimeters include all of the following features as standard:

SUPERIOR RELIABILITY

To ensure high reliability, Beckman Industrial Corporation uses a high-performance CMOS analog-to-digital converter integrated circuit that directly drives a multiplexed liquid crystal display. Because active multimeter functions are performed by this one integrated circuit, the total number of electronic parts in the basic multimeter has been reduced. Reliability is further enhanced by 100 percent burn-in of each multimeter and complete factory test of every function and range.

GUARANTEED LONG-TERM ACCURACY

Specified accuracies are guaranteed for a full year. Long-term accuracy is assured through the use of an extremely stable, band-gap reference element and a high-precision, thin-film, voltage-divider network.

RUGGEDNESS

The Model 4410 is designed to give years of trouble-free operation under normal use. The heavy-duty Model HD140 is designed to take accidental

falls and still meet specified accuracies. The liquid-crystal-display and single rotary switch are both recessed and sealed to prevent damage while in a tool box or on the job. The case has been designed to keep out dirt, dust, liquids, and other fluid contaminants that can cause malfunctions in other multimeters.

WATERPROOF (MODEL HD140 ONLY)
The meter has been completely O-ring sealed around the case, the range selection knob, and the four screws that gain access to the circuitry inside the unit. The display window is gasketed and ultrasonically sealed in the case for a tight, waterproof seal. The input terminal jacks are O-ring sealed to keep moisture out.

OVERLOAD PROTECTION
All inputs are protected against *continuous* overload conditions beyond the capability of the multimeter that may result from the measurement of unknown signals or from operator error. Also, all voltages and resistance ranges are protected against voltage transients up to six kV, ten microseconds duration by a metal-oxide varistor.

EASE OF USE
A single switch turns on power and selects both function and the desired range. The liquid-crystal-display is easy to read both indoors and outdoors even in direct sunlight.

DIODE TEST
Accurate measurements can be made of forward voltage drops across diodes and transistor junctions.

LOW BATTERY INDICATOR
The symbol "BT" appears in the display when the battery has approximately 10 hours of operational life remaining.

VERSATILE
Small, lightweight, and completely portable, the multimeter has a handy tilt bail for easy positioning and antiskid pads to keep it in place. Perfect for field, lab, or home use.

COMPLETE AND READY TO USE

Multimeters are shipped with battery and fuse installed. Remove the multimeter from the box and it is ready to use. Also included with each multimeter is a spare fuse, TL-245 Probe Set, and a complete operator's manual.

ACCURACY OF DC VOLTAGE READINGS

Multimeters have a basic accuracy of 0.05% of reading in DC volts.

NOTE

The symbol ⚠ on the front panel of the multimeter is an international symbol meaning "REFER TO OPERATING INSTRUCTIONS." Warnings and precautions to avoid personal injury and multimeter damage are listed in Paragraph 4.1.

Section Two
SPECIFICATIONS

Specifications are subject to change without notice.

2.1 GENERAL

The following specifications apply to the Models 4410 and HD140 Digital Multimeters.

OPERATING TEMPERATURE RANGE
0°C to +50°C

STORAGE TEMPERATURE RANGE
−40°C to +65°C with battery removed

DISPLAY
4½-digit and liquid-crystal-display (LCD) with a maximum reading of 19999

POWER
Single, standard nine-volt battery, NEDA 1604

BATTERY LIFE
Zinc-Carbon: 100 continuous hours, nominal

LOW BATTERY INDICATOR
Symbol "BT" appears in Digital Display with 10 hours battery life remaining.

SHOCK AND VIBRATION
Meets MIL-T-28800 specifications

RELATIVE HUMIDITY
0% to 80%, 0°C to 35°C; 0% to 70%, 35°C to 50°C

TEMPERATURE COEFFICIENT (0°C to 18°C, 28°C to 50°C)
Less than 10% of applicable accuracy specification per °C

DIMENSIONS
6.90 inches (17.4 cm) long × 3.70 inches (9.3 cm) wide × 1.87 inches (4.6 cm) high

ANNUNCIATOR SYMBOLS
"−," Negative Sign; Positive Sign is implied
"AC," AC Function Selected
"Ω," Continuity is detected (Insta-Ohms)
"BT," Low Battery
"I", Input is exceeding selected range

WEIGHT
18 ounces (499 grams) including battery

CALIBRATION
Accuracy specifications guaranteed for one (1) year, 23°C ±5°C

MEASUREMENT RATE
Two measurements per second, nominal

CASE
High-impact ABS plastic, fire retardant

MULTIMETER INCLUDES:
1. Nine-volt battery
2. Spare fuse
3. TL-245 Probe Set
4. Operator's manual

2.2 DC VOLTS

The following specifications apply to the Models 4410 and HD140 unless otherwise indicated.

RANGE	RESOLUTION	ACCURACY 23°C ±5°C
±200 mV	10 μV	.05% ±2 digits
±2V	100 μV	.06% ±2 digits
±20V	1 mV	.07% ±2 digits
±200V	10 mV	
±1500	100 mV	

INPUT IMPEDANCE (ALL RANGES)
10 megohms

NORMAL-MODE REJECTION RATIO
Greater than 60 dB, 45 Hz to 1 kHz

COMMON-MODE REJECTION RATIO (1 kΩ UNBALANCE)
Greater than 140 dB to 1500 VDC
Greater than 120 dB, 45 Hz to 400 Hz, to 1000 VAC

MEASUREMENT RESPONSE TIME
Less than one second

OVERVOLTAGE PROTECTION
1500 VDC or peak AC on 2V through 1500V ranges
1000 VDC or peak AC on 200 mV range
Six kV transients, ten microseconds duration

2.3 AC VOLTS

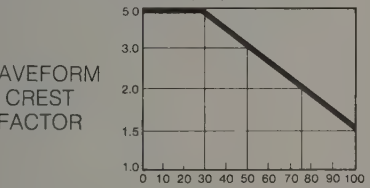
The following specifications apply to the Models 4410 and HD140, unless otherwise indicated.

		ACCURACY, 10% TO 100% OF RANGE +23°C ±5°C		
RANGE	RESOLUTION	45 Hz to 2 kHz	2 kHz to 5 kHz	5 kHz to 10 kHz
200 mV	10 μV	0.5% ±20 digits		
2V	100 μV	±0.5% ±20 digits	±0.5% ±30 digits	±1.0% ±40 digits
20V	1 mV			
200V	10 mV			
1000V	100 mV	45 Hz to 1 kHz ±0.5% ±20 digits		

INPUT IMPEDANCE (ALL RANGES)
10 megohms shunted by less than 100 pF.

TRUE RMS, AC COUPLED

CREST FACTOR (PEAK/RMS RATIO)
Varies from 1 to 5. See following graph.



MEASUREMENT RESPONSE TIME
Less than two seconds

OVERVOLTAGE PROTECTION
1000 VRMS (1500V peak) or 1500 VDC on 2V through 1000V ranges
500 VRMS or 400 VDC on the 200 mV range

2.4 DC CURRENT
The following specifications apply to the Models 4410 and HD140 unless otherwise indicated.

RANGE	RESOLUTION	ACCURACY, 23°C ±5°C
±200 μa	10 nA	0.2% ±2 digits
±2 mA	100 nA	
±20 mA	1 μA	0.3% ±2 digits
±200 mA	10 μA	
±2A	100 μA	0.5% ±2 digits
±10A	1 mA	1.0% ±2 digits

VOLTAGE BURDEN
200 μA to 200 mA: 250 mV maximum at fullscale
2 amperes: 750 mV maximum at fullscale
10 amperes: 250 mV maximum at 10 amperes

OVERCURRENT PROTECTION
A input: 2 amperes, 600V (fused)
10A input: 10 amperes continuous,
20 amperes for 30 seconds (unfused)

RESPONSE TIME
Less than 1 second

2.5 AC CURRENT

The following specifications apply to the Models 4410 and HD140 unless otherwise indicated.

		ACCURACY, 10% TO 100% OF RANGE +23°C ±5°C
RANGE	RESOLUTION	45 Hz to 1 kHz
200 μA	10 nA	0.7% ±20 digits
2 mA	100 nA	
20 mA	1 μA	0.8% ±20 digits
200 mA	10 μA	
2A	100 μA	1.0% ±20 digits
10A	1 mA	±1.5% ±20 digits

VOLTAGE BURDEN
200 μA to 200 mA: 250 mV maximum at fullscale
2 amperes: 750 mV maximum at fullscale
10 amperes: 250 mV maximum at 10 amperes

OVERCURRENT PROTECTION
A input: 2 amperes, 600V (fused)
10A input: 10 amperes continuous,
20 amperes for 30 seconds (unfused)

TRUE RMS, AC COUPLED

RESPONSE TIME
Less than 2 seconds

2.6 RESISTANCE
The following specifications apply to the Models 4410 and HD140 unless otherwise indicated.

RANGE	RESOLUTION	TEST CURRENT ±10%	ACCURACY 23°C ±5°C
2K	0.1 Ω	1 mA	±0.1% ±2 digits
20K	1 Ω	100 μA	
200K	10 Ω	10 μA	
2M	100 Ω	1 μA	
20M	1 KΩ	0.1 μA	±0.3% ±2 digits

MAXIMUM OPEN-CIRCUIT VOLTAGE
4 volts

MAXIMUM IN-RANGE VOLTAGE
2 volts

RESPONSE TIME
Less than 1 second on 2K, 20K, and 200K ranges
Less than 2 seconds on 2M and 20M ranges

OVERLOAD PROTECTION
500 VDC or RMS AC, any range (Model 4410)
600 VDC or RMS AC, any range (Model HD140)

2.7 DIODE TEST

Diode test measurements can easily be performed with the resistance function. (Refer to Paragraph 4.6.).

2.8 INSTA-OHMS QUICK CONTINUITY INDICATOR

RESPONSE TIME
Less than 100 milliseconds

Section Three
PREPARATION FOR USE

This section contains paragraphs that describe the following: unpacking and inspection, installation, controls, indicators, connectors, and initial checkout procedure.

3.1 UNPACKING AND INSPECTION

Remove the multimeter from the shipping container. The box should contain the following items:

1. Multimeter
2. TL-245 Probe Set (one black, one red)
3. Operator's manual
4. Nine-volt battery (installed)
5. Two fuses (one installed and one spare inside the case). To gain access to inside of multimeter, see Paragraph 6.2.3.

Account for and inspect all of the above items. If any of the items are damaged or are missing, immediately return the complete package to the place of purchase for an exchange.

NOTICE

Retain the shipping container for use if the multimeter must be returned for exchange or repair.

3.2 INSTALLATION

The multimeter is shipped ready for use. The only action required by the user is to place the tilt bail in the desired position. Figure 1 shows the two alternative positions of the tilt bail. The tilt bail is moved from one position to another by squeezing the two sides of the bail together and then reinserting the tips in the desired position.

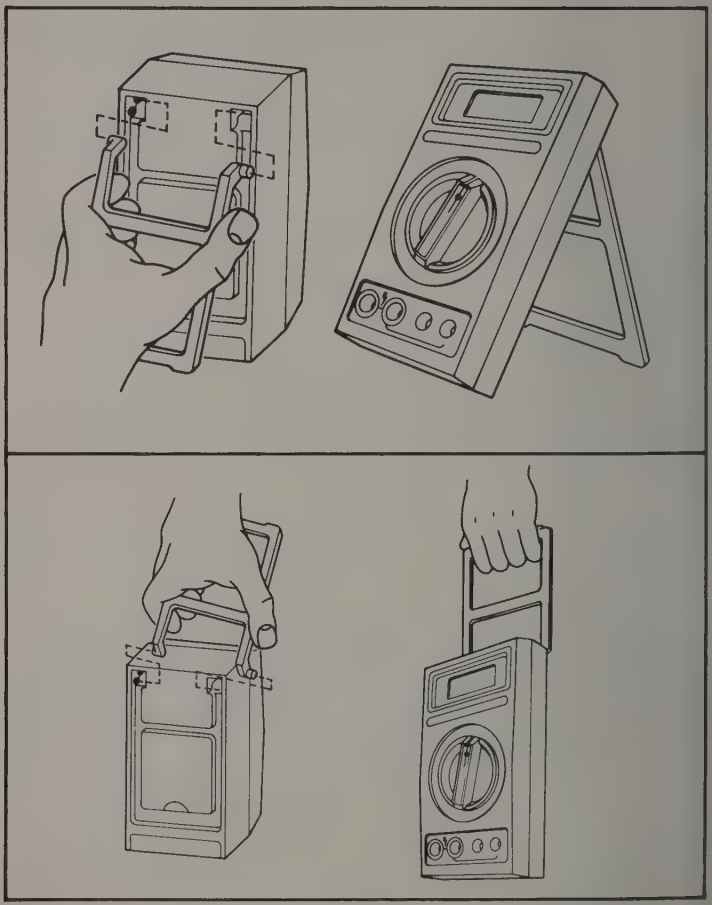


Figure 1. Positioning the Tilt Bail

3.3 MULTIMETER FAMILIARIZATION

This paragraph is designed to familiarize the user with the controls, indicators, connectors, and other features of the multimeter. It is HIGHLY RECOMMENDED that the user become familiar with the controls, indicators, and connectors shown and described in Figure 2 before operating the multimeter.

1. Digital Display
   A 4½ digit display (maximum reading 19999) with automatic decimal point placement, automatic polarity indication, overrange indication, low battery indication, and the Insta-Ohms Quick Continuity Indicator (Ω) indicates measured input value in volts, amperes, or ohms as selected by the Function/Range Switch.
2. Function/Range Switch
   This is the only control on the multimeter and greatly simplifies the operation. The one switch turns the multimeter off and on, selects the function, and selects the desired range. Five functions can be selected by directing the pointer on the center bar to: DCV, ACV, DCA, ACA, or Ω (ohms). The DCV function provides five ranges from 200 mV to 1500 volts DC. The ACV function provides five ranges from 200 mV to 1000 volts RMS AC. The DCA and ACA functions each provide five ranges of current measurements from 200 μA to 2A fullscale. The 20m/10A positions in the DCA and ACA functions serve two purposes. When using the "A" input jack, the 20m/10A position serves as the 20 mA range. When using the "10A" input jack, the 20m/10A position serves as the 10A range. The multimeter thus provides a total of six current ranges for both DC and AC current. The (ohms) function provides five ranges of resistance measurements from 2000 ohms to twenty megohms. The continuity test function operates in any resistance range.
3. 10A Input Connector
   Banana jack connector used for continuous current measurements from zero to ten amperes. Measurements between ten and twenty amperes for a duration of thirty seconds maximum may also be made using this terminal. Inputs beyond this maximum may cause damage to the multimeter.

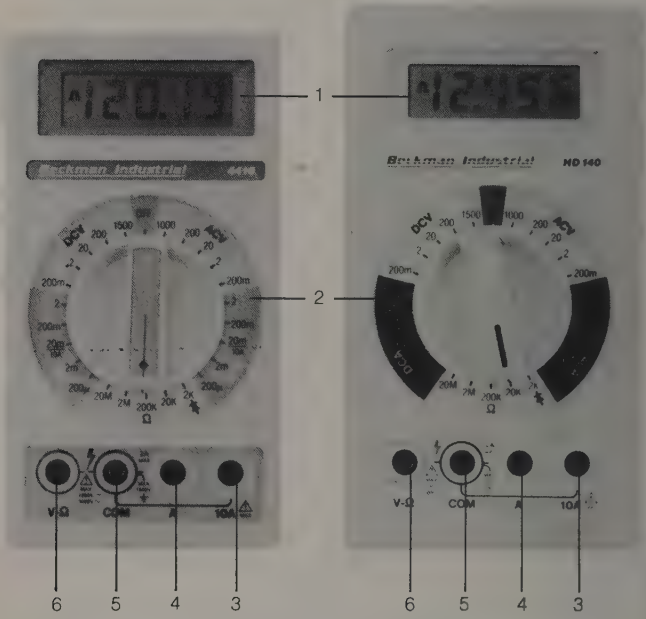


Figure 2. Operating Controls, Indicators, and Connectors

4. A Input Connector
   Banana jack connector used for current measurements up to two amperes. The multimeter is protected by a fuse against inputs over two amperes with an open-circuit voltage of 600 VDC or peak AC or less.
5. COM Input Connector (black)
   Banana jack connector used as the common or low input for all measurements.
6. V·Ω Input Connector
   Banana jack connector used as the high input for all voltage and resistance measurements.

3.4 INITIAL CHECKOUT

Before placing the multimeter into use, a simple checkout procedure will ensure that it is working properly. The only equipment required is the test leads.

1. Be certain that battery and fuse are installed properly, see Paragraphs 6.2.2 and 6.2.3.
2. Connect the red test lead to the V·Ω Input Connector and the black test lead to the COM Input Connector.
3. Place the Function/Range Switch in the maximum DCV position.
4. Touch the red test lead and black test lead together. Observe the Digital Display; it should read 000.0 ± .2.
5. Turn the Function/Range Switch counterclockwise to each DCV position while observing the Digital Display. With the test lead tips in contact, the Digital Display should read zero plus or minus two digits and the decimal point positioned as follows:

   200 V 00.00
   20 V 0.000
   2 V .0000
   200 mV 00.00
6. Turn the Function/Range Switch to the 20 MΩ position. With the two test lead tips separated, the Digital Display should read "1" (overrange).
7. Touch the test lead tips together and observe the Digital Display; it should read 0.000 ± .002.

8. Turn the Function/Range Switch to each ohm position while observing the Digital Display. With the test lead tips in contact, the Digital Display should read zero ±2 counts in each position.

    20 MΩ 0.000
    2 MΩ .0000
    200 kΩ 00.00
    20 kΩ 0.000
    2 kΩ .0000

9. Turn the Function/Range Switch to the maximum ACV position

WARNING

The next step requires the measurement of the local AC line (mains) voltage. Be careful not to touch the test lead tips with fingers and do not allow the tips to contact each other.

10. Measure the local line (mains) voltage at a convenient AC power outlet. The Digital Display should show the appropriate voltage with a resolution of 100 mV.
11. Remove both probes from the AC outlet.
12. If the multimeter has performed properly during this checkout procedure, it is fully operational and ready to use.

Section Four
OPERATING INSTRUCTIONS

This section of the manual describes the various operating modes of the multimeter as well as a summary of warnings and precautions.

4.1 WARNINGS AND PRECAUTIONS

The following warnings and precautions are intended to protect the user from injury and the multimeter from damage.

4.1.1 WARNINGS

1. The TL-245 Probe Set, supplied with the multimeter, is designed specifically for use with the Models 4410 and HD140 Multimeters. Users should not attempt to measure voltages or currents that may exceed the ratings marked on the Function/Range Switch or terminal overlays.
2. Use extreme caution when working near high-voltage sources. This includes any voltage measurements requiring the use of the two highest VAC or VDC ranges.
3. To avoid electrical shock hazard and/or damage to the multimeter, do not measure voltages that might exceed the maximum voltage rating above earth ground shown on the terminal overlays.
4. Operator injury or damage to the multimeter may occur during current measurements if the fuse blows in a circuit which exhibits an open-circuit voltage greater than 600 VDC or AC peak.
5. Before each use of the multimeter, inspect test leads, connectors, and probes for cracks, breaks, or crazes in the insulation. If any defects are found, replace item immediately.
6. To avoid electrical shock hazard, do not touch test leads, tips, or the circuit being tested while power is applied to the circuit being measured.

4.1.2 PRECAUTIONS

1. Exceeding the maximum input overload limits can damage the multimeter.
2. When making current measurements, make sure that the multimeter is connected in series with the load in which the current is to be measured. NEVER connect the multimeter ACROSS a voltage source. To do so, can result in either blowing the overload protection fuse or damaging the device being tested.

4.2 OVERLOAD INDICATION

The Models 4410 and HD140 Multimeters are equipped with automatic overload indication. This means that whenever an input signal is larger than the range selected, an OVERLOAD symbol ("1") will appear in the Digital Display, see Figure 7. This feature allows the user to test devices with unknown circuitry where an overload condition might exist but would not exceed the capability of the multimeter. See Section Five for a complete description of overload protection.

4.3 VOLTAGE MEASUREMENTS

4.3.1 DC VOLTAGE

1. Connect red test lead to V·Ω Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired DCV position. If the magnitude of voltage is not known, set switch to highest range and reduce setting until satisfactory reading is obtained.
3. Turn off power to device or circuit being tested and discharge all capacitors.

WARNING

To avoid electrical shock hazard and/or damage to the multimeter, do not attempt to measure voltages that might exceed the maximum voltage rating.

4. Connect test leads to device or circuit being measured.
5. Turn on power to device or circuit being measured. Voltage value will appear on Digital Display along with the voltage polarity.
6. Turn off power to device or circuit being tested and discharge all capacitors before disconnecting test leads from device or circuit being tested.

4.3.2 AC VOLTAGE

1. Connect red test lead to V·Ω Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired ACV position. If the magnitude of voltage is not known, set switch to highest range and reduce setting until satisfactory reading is obtained.

3. Turn off power to device or circuit being tested and discharge all capacitors.

WARNING

To avoid electrical shock hazard and/or damage to multimeter, do not attempt to measure voltage that might exceed 1000 volts RMS or 1500 volts peak.

4. Connect test leads to device or circuit being measured.
5. Turn on power to device or circuit being measured. Voltage value will appear on Digital Display.
6. Turn off power to device or circuit being tested and discharge all capacitors before disconnecting test leads from device or circuit being tested.

4.3.3 TRUE RMS MEASUREMENTS

Models 4410 and HD140 permit direct measurement of the true RMS value of an input signal.

RMS is defined by the expression:

$$\text{True RMS} = \sqrt{(\text{AC RMS Component})^2 + (\text{DC component})^2}$$

Physically, RMS is equivalent to that DC value which dissipates the same amount of power in a resistor as the original signal and can be visualized by the relationships

$$\text{Power} = \frac{E_{RMS}^2}{R} = \frac{E_{DC}^2}{R}$$

and

$$\text{Power} = I^2_{RMS} R = I_{DC}^2 R$$

"Average-responding" meters provide accurate RMS readings for sinusoidal signals, but can introduce significant errors when measuring complex waveforms.

Models 4410 and HD140 are AC coupled in the AC function and will accurately measure the AC RMS component of an input signal. The DC

voltage function will measure the DC component. To obtain the total true RMS value, measure the RMS AC component on the AC function and the DC component on the DC function. Then, calculate the True RMS value, using the measured AC and DC components and the True RMS expression given above.

Figure 3 shows some common waveforms and the corresponding display readings for DC- and AC-coupled True RMS meters and an average-responding RMS meter.

AC converters of all types are limited by their frequency response and input dynamic range. Measurements of complex waveforms will not be affected by converter bandwidth limitations, provided that all significant AC components contained within the waveforms are within the bandwidth of the converter.

Crest factor is a measure of the input dynamic range of an AC converter. It expresses the ability of the converter to accept a signal that has large peak values compared to its RMS value without saturating the converter circuitry and degrading the specified accuracy.

For the Models 4410 and HD140, crest factor is defined as the ratio of the peak voltage to the total AC RMS voltage.

$$\text{Crest Factor} = \frac{\text{V peak}}{V_{\text{AC RMS}}}$$

Crest factors for the Models 4410 and HD140 range from 1.0 to 5.0 on each voltage or current AC range, depending on the AC RMS value of the signal being measured. At fullscale (19,999 counts), signals with crest factors between 1.0 to 1.5 can be measured. At halfscale (10,000 counts) signals with a crest factor between 1.0 and 3.0 can be measured without performance degradation. At 6000 counts and below, signals with crest factors up to 5.0 can be measured.

Crest factors of some common waveforms are given in Figure 3 for both DC coupled and AC coupled waveforms.

If the crest factor of a waveform is not known, determine the crest factor as follows:

For AC coupled True RMS meters (Models 4410 and HD140), AC couple the waveform to an oscilloscope and measure the peak voltage with respect to the ground reference. Divide the peak voltage by the RMS voltage measured by the multimeter. The resultant is the crest factor.

4.4 CURRENT MEASUREMENTS

4.4.1 DC CURRENT

1. Connect red test lead to the A Input Connector for current measurements up to two amperes. For current measurements between two and ten amperes, connect red test lead to the 10A Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired DCA position. If the magnitude of current is not known, set switch to highest range and reduce setting until satisfactory reading is obtained. When the 10A Input Connector is used, the Function/Range Switch should be placed in the 20m/10A position.
3. Turn off power to device or circuit being tested and discharge all capacitors.
4. Open circuit in which current is to be measured. Securely connect test leads in series with the load in which current is to be measured.
5. Turn on power to circuit being tested.
6. Read current value on Digital Display.
7. Turn off all power to circuit being tested and discharge all capacitors.
8. Disconnect test leads from circuit and reconnect circuit that was being tested.

4.4.2. AC CURRENT

1. Connect red test lead to A Input Connector for measurements up to two amperes. For current measurements between two and ten amperes, using models with ten-ampere capability, connect red test lead to 10A Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired ACA position. If the magnitude of current is not known, set switch to highest range and reduce setting until satisfactory reading is obtained. When the 10A Input Connector is used, the Function/Range Switch should be placed in the 20m/10A position.
3. Turn off power to device or circuit being tested and discharge all capacitors.
4. Open circuit in which current is to be measured. Securely connect test leads in series with the load in which the current is to be measured.
5. Turn on power to circuit being tested.

Meter Display Reading			
INPUT WAVEFORM	AC + DC TRUE RMS $AC_{RMS} = \sqrt{AC^2 + DC^2}$	AC TRUE RMS (MODELS 4410 AND HD140)	AC RMS AVERAGE RESPONDING
Sine A O −A	0.707 A CF = 1.414	.707 A CF = 1.414	.707 A
Square A O −A	1.000 A CF = 1.000	1.000 A CF = 1.000	1.111 A
Triangle A O −A	0.577 A CF = 1.733	0.577 A CF = 1.733	0.555 A
Full Wave Rectified Sine A O	0.707 A CF = 1.414	0.308 A CF = 3.247	0 298 A
Half Wave Rectified Sine A O	0.500 A CF = 2.000	0.386 A CF = 2.591	0 389 A
50% Duty Cycle Pulse Train A O T_0 T_1 $T_0 = T_1$	0.707 A CF = 1.414	0.500 A CF = 2.000	0.555 A

Figure 3. Typical Input Waveforms with Corresponding Meter Display Readings and Crest Factors (CF)

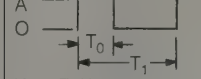
Meter Display Reading			
INPUT WAVEFORM	AC + DC TRUE RMS $AC_{RMS} = \sqrt{AC^2 + DC^2}$	AC TRUE RMS (MODELS 4410 AND HD140)	AC RMS AVERAGE RESPONDING
Variable Duty Cycle Pulse Train  $X = T_0/T_1$ $Y = \sqrt{X - X^2}$	$A\sqrt{X}$ $CF = A/\sqrt{X}$	AY $CF = A/Y$	1.111 AY

Figure 3. Typical Input Waveform with Corresponding Meter Display Readings and Crest Factors (CF) (Continued)

6. Read current value on Digital Display.
7. Turn off all power to circuit being tested and discharge all capacitors.
8. Disconnect test leads from circuit and reconnect circuit that was being tested.

4.5 RESISTANCE MEASUREMENTS

1. Connect red test lead to V·Ω Input Connector. Connect black test lead to COM Input Connector.
2. Set Function/Range Switch to desired ohm position. If the magnitude of resistance is not known, set switch to highest range and reduce setting until satisfactory reading is obtained.
3. If the resistance being measured is connected to a circuit, turn off power to circuit being tested and discharge all capacitors.
4. Connect test leads to circuit being measured. When measuring high resistance be careful not to contact adjacent points, even if insulated. Some insulators have a relatively low insulation resistance, which can cause the measured resistance to be lower than the actual resistance.
5. Read resistance value on Digital Display. If a high resistance value is shunted by a large value of capacitance, allow the Digital Display to stabilize.

4.6 DIODE AND TRANSISTOR TEST MEASUREMENTS

Diode test measurements can be easily performed with the resistance function. When this function is selected, a constant-current source is connected to the V-Ω input jack, resulting in the flow of a source current between the V-Ω and COM input jacks. Magnitude of the current ranges from 0.1 microamperes to 1000 microamperes, depending on range selection. Refer to Table 1.

4.6.1 DIODE TESTS

To measure the forward bias voltage of a diode (semiconductor junction), connect the anode to the V-Ω (+) input jack and the cathode to the COM (−) input jack. Select the resistance range for the desired current (see Table 1) and read the diode forward bias voltage on the display.

Readings are displayed in volts. A numeral "1" is displayed for overrange voltages greater than 2 volts. The open-circuit voltage between the V-Ω and COM input jacks is 4 volts.

The decimal point is correctly displayed only in the 2M and 2K ranges.

Table 1.

Resistance Range	Constant Current Source Output ±10%
2K	1000 μA
20K	100 μA
200K	10 μA
2M	1 μA
20M	0.1 μA

On the 20M, 200K, and 20K ranges, the operator will have to mentally reposition the decimal point to where it is displayed on the 2M and 2K ranges.

For a silicon diode, the typical forward bias voltage at 1 milliampere (2K range) ranges from 0.6 to 0.7 volts. A reverse-biased diode should cause the display to show a numeral "1", indicating a reverse leakage resistance of greater than 2K ohms.

4.6.2 TRANSISTOR JUNCTION TESTS

Transistors can be tested in the same manner as diodes by checking the two diode junctions formed between the base and emitter and the base

and collector of the transistor. (See Figure 4.) Measurements between the collector and emitter should also be made to determine if a short circuit is present.

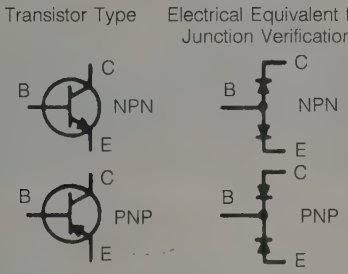


Figure 4. Orientation of Effective Diode Junctions for PNP and NPN Transistors

4.6.3 TRANSISTOR BETA TEST

With a simple test fixture provided by the user, the resistance function, set to the 2K range, can be used to determine the DC current gain (beta) of a transistor. Beta is measured using DC collector-to-emitter (VCE) voltage of about 1 volt at a collector-current of about 1 milliampere.

The transistor beta test setup is shown in Figure 5 for an NPN transistor. For PNP transistors, the connections to the multimeter should be reversed.

$$\text{Beta} = \frac{2000}{\text{Display Change in Digits}}$$

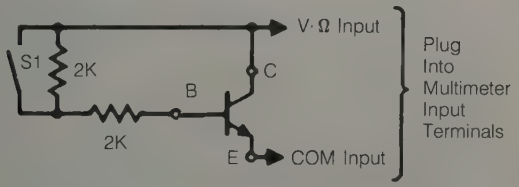


Figure 5. Test Fixture for Transistor Beta Measurement

To determine transistor beta, use the following procedure:

1. With all the connections as shown in Figure 5, and with S1 open, record the displayed reading.

NOTICE

If an overload indication is obtained, reverse the connections to the multimeter.

If an overload indication is obtained regardless of meter orientation, the transistor is probably defective.

2. Close S1 and record the new displayed reading.
3. Divide 2000 by the difference of the readings, in digits, taken in Steps 1 and 2. The resulting number is the DC beta of the transistor.

4.7 CONTINUITY AND CAPACITOR CHECKS

Before the Beckman Digital Multimeter, quick continuity checks using a digital volt/ohm meter were not possible. Now they can be done just as quickly and as easily as with an analog meter. This feature is particularly useful in circuit and cable tracing, but also may be used for troubleshooting small-value capacitors.

4.7.1 CONTINUITY CHECKS

1. Place Function/Range Switch in any ohm range.
2. Connect red test lead to the V·Ω Input Connector. Connect the black test lead to the COM Input Connector. With the test leads separated or measuring an out-of-range resistance, the Digital Display will indicate "1" (overload), Figure 6.

3. Place one test lead probe at one end of cable or circuit to be tested. Use the other test lead to trace the circuit or cable until the circuit is complete. When continuity is established, an ohm symbol will appear in the left-hand portion of the Digital Display, Figure 7. If contact in the cable or circuit is maintained long enough (about one-quarter of a second), the "1" will disappear and the resistance value of the cable or circuit will appear next to the ohm symbol, Figure 8.

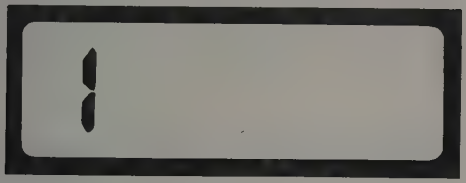


Figure 6. Display of Overload Symbol

Figure 7. Display of Insta-Ohms Quick Continuity Indicator (Ω)

Figure 8. Display of Insta-Ohms Quick Continuity Indicator Ω and Resistance Value

NOTICE

The Insta-Ohms Quick Continuity Indicator quickly identifies completed circuit paths. Resistance values of fullscale or less will enable the ohm symbol (Ω).

4.7.2 CAPACITOR CHECKS

The Insta-Ohms Quick Continuity Indicator also can be used as a rough check of capacitors with a value of greater than or equal to 0.05 μF. This feature can be a great aid in troubleshooting circuits in which an open or shorted bypass capacitor is suspected. Use the following procedure to check capacitors.

1. Place Function/Range Switch in 20 MΩ range position.
2. Connect red test lead to V·Ω Input Connector. Connect the black test lead to the COM Input Connector. With the test leads separated the Digital Display will indicate "1" (overload), Figure 6.
3. Discharge the capacitor to be checked by briefly shorting the capacitor ends.
4. Place red test lead probe at one end of capacitor. Place the black test lead at other end of capacitor.

NOTICE

Do not touch capacitor leads or test probe ends during capacitor check because proper operation of Insta-Ohms feature could be affected.

5. If the Insta-Ohms symbol (Ω) appears briefly and then disappears, the capacitor is accepting a charge. If the Insta-Ohms symbol does not appear, reverse the test leads. If the Insta-Ohms symbol still does not appear, the capacitor is probably open. If the capacitor is shorted, a low resistance value will be displayed.

4.8 DECIBEL MEASUREMENTS

In addition to its normal functions, the multimeter can be used to measure decibels. The value obtained from this measurement can be used to indicate the gain and accuracy of electronic devices. The decibel (dB) is the logarithm of the ratio of two electrical signals; usually a certain amount of power dissipated in a fixed resistance is used as a reference and denoted as 0

(zero) decibels. In Figure 9, zero decibel is defined as one milliwatt into 600 ohms. Use the procedure of Paragraph 4.3.2 to determine AC voltage and the graph of Figure 9 to determine decibel value.

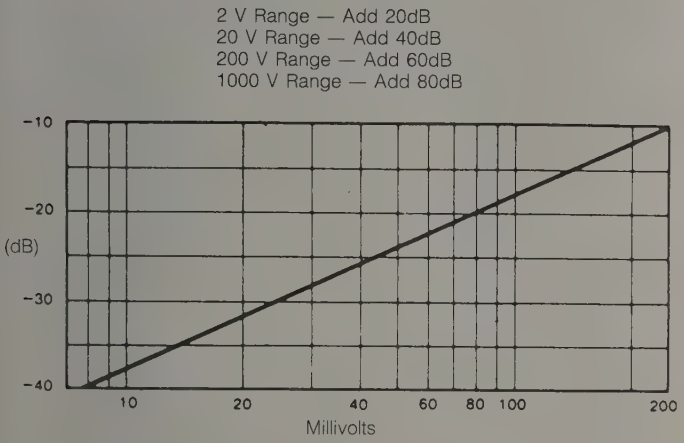


Figure 9. Decibel Conversion Chart

Section Five
THEORY OF OPERATION

5.1 GENERAL

The central part of a Beckman Industrial Corp. Digital Multimeter is the single-chip, CMOS integrated analog-to-digital (A/D)converter chip. The A/D chip converts a DC analog input into a digital equivalent which then directly drives a triplexed liquid crystal display (LCD).

Peripheral components are used with this chip to perform a range of voltage, current, and resistance measurements. Included in these peripheral circuits are the following:

- Voltage divider and resistance reference network
- A true RMS AC-to-DC converter
- An ohms source
- An Insta-Ohms detection circuit
- A precision voltage reference
- An active filter
- An annunciator control circuit
- A triplexed liquid crystal display
- Input protection circuits
- A Function/Range Switch
- Power supply circuits
- Battery

5.2 OVERALL FUNCTIONAL DESCRIPTION

A simplified block diagram is shown in Figure 10 and the circuit schematic diagrams in Figures 12 and 13. The Function/Range Switch routes the input signal to an appropriate input conditioning circuit(s), which scales, and/or converts, the applied input signal into a DC voltage.

The DC voltage is then filtered by an active filter for normal-mode rejection of interfering power line and audio-frequency noise.

The DC voltage is presented to the input of the A/D, which converts the DC to a digital equivalent that directly drives the liquid crystal display (LCD). The displayed reading is an accurate digital display of the applied input signal.

Decimal point positions on the display are determined automatically by the A/D according to the position selected on the Function/Range Switch.

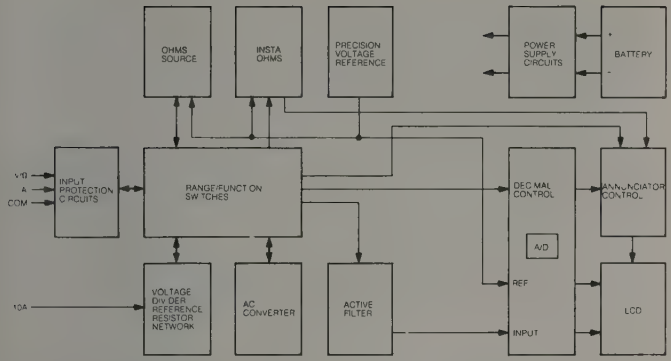


Figure 10. Simplified Block Diagram of 4½ Digit Multimeter

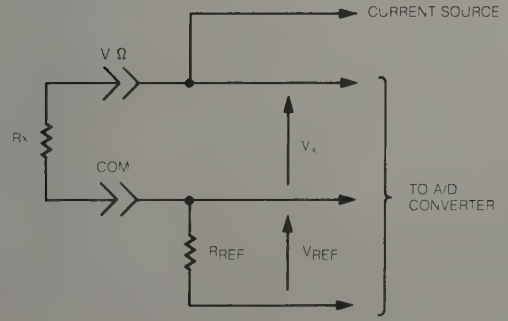


Figure 11. Input Conditioning Circuit for Resistance Measurements

The "BT" symbol on the LCD is automatically displayed when the battery is low and should be replaced.

The "AC" symbol is displayed when any AC function is selected.

The "Ω" symbol is displayed when the resistance function is selected and a resistance of the fullscale value or less is connected across the V-Ω and COM input jacks.

Resistances greater than the fullscale value will cause a numeral "1" to be displayed on the LCD, indicating an over-range value.

The polarity of a DC (voltage or current) input is indicated by display of a minus sign (–) for negative inputs and by the absence of a sign for positive inputs.

A positive voltage or current over-range reading causes a numeral "1" to be displayed on the LCD; a negative over-range reading results in display of a "–1."

5.3 BLOCK DIAGRAM ANALYSIS

5.3.1 INPUT PROTECTION CIRCUITRY

Input protection circuitry has been provided to protect the instrument from normally encountered overloads and function and range selection errors.

In the voltage ranges, primary over-voltage protection is provided by a 510K Ω series resistor (R17). This resistor limits the input current to the A/D to tolerable levels when the input exceeds 1500 VDC. Secondary protection from energy-limited transients up to 6000 volts is provided by a metal-oxide varistor (MOV).

In the resistance ranges, protection is provided by a positive-temperature-coefficient resistor (PTC), zener diodes VR1 and VR2, and diode bridge DB2.

In the "A" current ranges, protection from over-current and over-voltage is provided by a 2 ampere, 600V fuse and a diode bridge (DB1). The fuse will open for long-term overloads, and the diode bridge diverts overloads from the current measurement resistors. Although not fuse-protected, the ten-ampere current input connects directly to a durable 10 milliohm resistor which can withstand ten amperes continuously and up to 20 amperes for 30 seconds.

5.3.2 INPUT CONDITIONING CIRCUITS

When measuring either voltage or current, the A/D circuit accurately converts an unknown DC voltage input within the range of −200 millivolts to +200 millivolts into a digital equivalent which is displayed on the LCD. If the input signal is other than a DC voltage in the ±200 millivolt range, the signal must be conditioned to be within this range.

5.3.3 VOLTAGE MEASUREMENTS

A precision-ratio voltage attenuator is used to reduce both AC and DC voltages when the input signals exceed the 200 millivolt limit. If the ±200 mV DC range is selected, the input signal feeds directly to the A/D input. On all higher voltage ranges, a precise power-of-ten tap is selected on the voltage attenuator, which is then connected to the A/D input.

On the AC ranges, AC input waveforms are scaled using the voltage attenuator in the same manner as for the DC input voltages. The appropriate output tap on the voltage divider is selected and is AC coupled to a true RMS AC converter. The converter converts the AC input waveform into a proportional DC output which is coupled to the A/D for conversion.

5.3.4 RESISTANCE MEASUREMENTS

Resistance measurements are made with a ratio technique, where an unknown resistance is compared to an internal resistance standard. As shown in Figure 11, the unknown resistance is connected in series with a selected resistance standard and a current source. Because of negligible loading at the sensing terminals of the A/D converter, the ratio of the two resistors is equal to the ratio of their respective voltage drops.

$$\frac{V_x}{R_x} = \frac{V_{ref}}{R_{ref}}$$

The A/D converter uses a ratiometric conversion technique which relies solely on the ratio of the unknown voltage, V_x to the reference voltage, V_{ref}.

When in the Resistance Function, the A/D is switched to convert DC input voltages (V_x), up to 2.000 volts, equivalent to the selected range at fullscale.

5.3.5 CURRENT MEASUREMENTS

DC current is converted into a DC voltage by passing the input current through a selected shunt resistor, resulting in a voltage drop within the proper

voltage range required by the A/D converter. In the AC current ranges, the shunt voltage drop is routed to the same RMS converter used in the conversion of AC voltages. The shunt resistors that are switched in series to make current shunt values range from 0.01Ω through 1K Ω.

5.3.6 INSTA-OHMS CONTINUITY INDICATOR

The Insta-Ohms quick continuity indicator allows a very quick determination of circuit continuity. Because the Insta-Ohms circuit is separate from the main A/D converter circuitry, normal conversion time is not required and indication of the "Ω" symbol in the digital display occurs almost immediately. Resistances of fullscale value or less will enable the "Ω" symbol.

This section of the manual describes the maintenance procedures, calibration, and troubleshooting. In addition, a general statement on service policy is included. Any questions regarding warranty repair or instrument servicing should be directed to Beckman Industrial Corp., at (714) 773-6885.

6.1 WARRANTY STATEMENT

The warranty statement for the Multimeter appears on the inside front cover of this manual. Read it carefully before requesting warranty repairs.

6.1.1 WARRANTY REPLACEMENT

Any Model 4410 or HD140 Multimeter claimed to be defective should be returned to Beckman Industrial Corp., with a $3.00 handling fee from within the Continental U.S.A.; $12.00 from elsewhere.* Follow the shipping instructions of Paragraph 6.1.3.

Warranty replacement will be made typically within two working days after receipt of defective unit.

6.1.2 NONWARRANTY REPAIRS

Any out-of-warranty meter that is defective, but repairable, can be repaired by an Authorized Service Center or by Beckman Industrial Corp. The repaired unit carries a three (3) month warranty. Contact any Authorized Service Center for their current nonwarranty repair rates. Repairs made at the Factory Service Center are at a $69.00 flat rate.* Include payment or purchase order with meter specifically authorizing repair and pay only $65.00.*

6.1.3 SHIPPING INSTRUCTIONS

A multimeter returned for calibration or repair should be shipped with the following information or items: company name, customer's name, address, telephone number, proof of purchase (warranty repairs), a description of the problem encountered or service required, and the appropriate service charge.

*Prices subject to change without notice.

Service charges should be remitted in either the form of a check, money order, or purchase order made payable to Beckman Industrial Corp.

A multimeter should be shipped with transportation charges prepaid to the following address:

Instrumentation Products Division
Beckman Industrial Corp.
630 Puente Street
Brea, CA 92621
Attn: Customer Service

A multimeter will be returned to the customer with transportation charges paid by Beckman Industrial Corp.

6.2 MAINTENANCE PROCEDURES

Regular operator maintenance of the multimeter consists of: cleaning case and window, battery replacement, and fuse replacement. All other repairs should be performed by a Factory Authorized Service Center or other qualified instrument service personnel.

6.2.1 CLEANING CASE AND WINDOW

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These chemicals will react with plastics used in construction of the case.

The front panel case should be cleaned with a mild solution of detergent and water. Apply sparingly with a soft cloth and allow to dry completely before using.

6.2.2 BATTERY REPLACEMENT (MODEL 4410)

WARNING

To prevent electrical shock hazard, turn off the multimeter and disconnect test leads before removing the back cover.

1. Remove two screws from battery cover.
2. Remove battery cover by pushing up and, then, pulling it out.
3. Lift battery from compartment.
4. Unsnap battery connector from battery and remove battery.

5. Snap battery connector onto new battery.
6. Insert battery into compartment.
7. Replace battery cover by pushing it forward and down.
8. Replace battery cover screws.

6.2.3 BATTERY REPLACEMENT (MODEL HD140)

To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing back cover.

1. After disconnecting test leads and turning off Multimeter, remove back cover by removing four screws, then lift off back cover.

CAUTION

Failure to turn off the instrument before installing the battery could result in damage to the battery if it is connected to the battery terminal incorrectly.

2. The battery is located in the front part of the case. Disconnect battery from instrument and replace with a standard 9-volt transistor battery.
3. Replace back cover and secure with four screws, taking care to seat O-ring seal uniformly.

6.2.4 FUSE REPLACEMENT (MODEL 4410)

1. Remove two screws from battery cover.
2. Remove battery cover by pushing up and, then, pulling it out.
3. Lift battery from compartment.
4. Grasp loose end of ribbon. Hold Multimeter with other hand and pull the ribon to release the fuse.
5. Remove old fuse.
6. Turn Multimeter over to allow spare fuse to drop out.
7. Replace center of ribbon across fuse opening and press new fuse into place. Be sure the ribbon is between the fuse clips, not caught on the clips.
8. Insert battery into compartment.
9. Replace battery cover by pushing it forward and down.
10. Replace battery cover screws.

WARNING

Do not operate multimeter with back cover removed (except during calibration).

6.2.5 FUSE REPLACEMENT (MODEL HD140)

WARNING

To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing back cover.

1. After disconnecting test leads and turning off Multimeter, remove back cover by removing four screws, then lift off cover.
2. The fuse is located in the upper half of the instrument. Remove old fuse and replace with spare.

WARNING

To prevent fire, use Type 2A/600V fuse only.

3. Replace back cover and secure with four screws.

WARNING

Do not operate Multimeter with back cover removed (except during calibration.

6.3 CALIBRATION

NOTE

For the AC portion of the calibration, Steps 5 through 10 of the following procedure, shield spacing is critical. The AC calibration must be performed with the shield in place and positioned as it would be in the closed, normally assembled, instrument.

At present this condition is obtained by temporary replacement of the standard back case with a special back case having holes for screwdriver access to the calibration adjustments. The special back case is assembled to the front case/module assembly, thus closely spacing the shield. The adjustments are then made through the holes.

1. Set meter to the 200 mV DC position.
2. Set the input voltage to 0 volts DC.
3. Adjust R18 on display board for a clear display. View the display with the LCD top tilted away from the viewer by approximately 25°.
4. Note the offset voltage displayed with the zero volt input. (Maximum offset should be ≤ ±00.02). Input +190.00 mV DC and adjust R20 for a displayed reading of +190.00 mV + offset.

   Example:

   If offset is −00.01, adjust R20 for a reading of +189.99 i.e., 190.00 + (−00.01).

   If offset is +00.01, adjust R20 for a reading of +190.01 i.e., 190.00 + 00.01.

   Reverse input leads and verify that the offset error reverses.

   If offset is −00.01, the display should read −190.01.

   If offset is +00.01, the display should read −189.99.
5. Set meter to the 200 mV AC position.
6. Input 190.00 mV AC at 400 HZ. Adjust R16 on the input board for a displayed reading of 190.00 mV ±.05 maximum.
7. Input 190.00 mV AC at 20 kHZ. Adjust C5 for a displayed reading of 190.00 ±0.5 maximum.
8. Switch the meter to the 20 V AC position. Input 19.000 V AC at 10 kHZ. Adjust C4 for a displayed reading of 19.000 ±.020 maximum.
9. Switch the meter to the 2 V AC position. Input 1.9000 V AC at 10 kHZ. Adjust C3 for a displayed reading of 1.9000 ±.0020 maximum.
10. Repeat steps 8 and 9 until displayed readings meet specifications without further adjustments to C3 or C4.

6.4 TROUBLESHOOTING

Except for the replacement of the battery or fuse, repair of the multimeter should be performed only by the Beckman Service Center or by other qualified instrument service personnel.

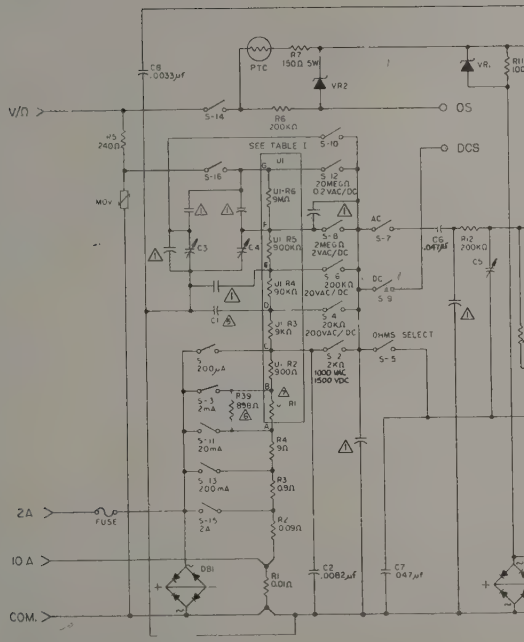
CAUTION

The CMOS integrated circuits are subject to damage created by electrostatic discharge. This component should be handled only by qualified personnel equipped with anti-static grounding devices.

If the multimeter is not performing properly, the following steps should be taken before returning it for warranty repair.

1. Check the battery and fuse connections.
2. Verify that the Function/Range Switch is in the correct position for the type of parameter and range of values being measured, and that the measurement value is within the capability of the multimeter.
3. Review and comply with the operating instructions contained in Section Four of this instruction manual.
4. Inspect the test leads for breaks or cracks, and ensure that the test leads are inserted fully into the input connectors.
5. Check to see that the ambient environment in which the multimeter is being used is within specifications given in Section Two of this instruction manual.
6. If the Digital Display shows "BT", the battery is probably low. Replace battery, using procedure of Paragraph 6.2.2 or 6.2.3.
7. If the Digital Display is blank with the unit turned on, the battery is probably dead. Replace battery, using appropriate procedure of Paragraph 6.2.2 or 6.2.3.
8. If operation is normal in all functions and ranges except AC and DC current, the fuse is probably blown. Replace fuse, using procedure of Paragraph 6.2.4 or 6.2.5.

If the preceding steps do not remedy the problem, refer to Paragraph 6.1.1 WARRANTY REPLACEMENT, and Paragraph 6.1.2 NONWARRANTY REPAIRS.



⚠ FOR A-B ATTN U1-R1 IS 90Ω
FOR OHMTEK ATTN U1-R1 IS 100Ω
④ USE WITH OHMTEK ATTEN ONLY
⑤ USE 470 PF (3000-120-100) WITH A-B ATTEN.,
USE 330 PF (3000-120-102) WITH OHMTEK ATTEN.
⑥ SELECTED IN TEST. FOR VALUE SEE DWG 3000-560-117
3 ALL CAPACITORS VALUES ARE IN PICOFARADS
2 ALL RESISTORS VALUES ARE IN OHMS
⚠ TRACE CAPS: C32, C33, C34, C35, C36, C37, C38

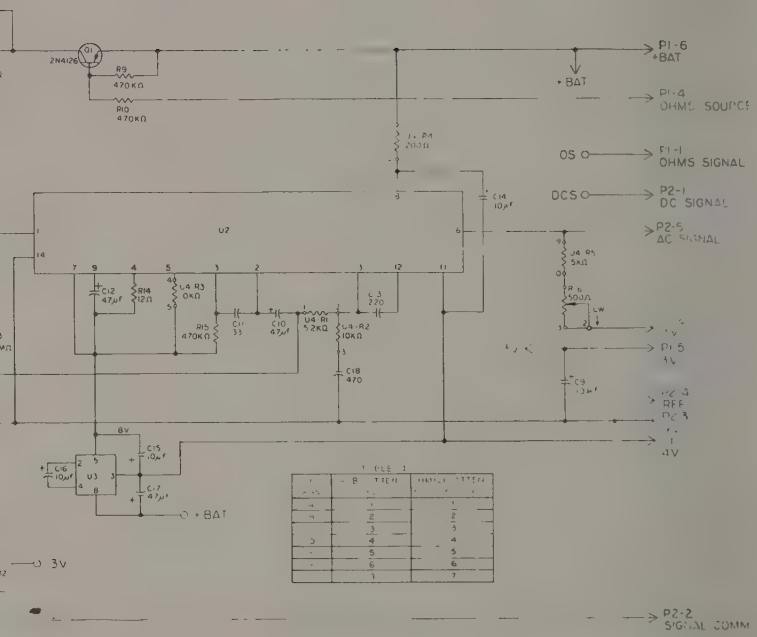
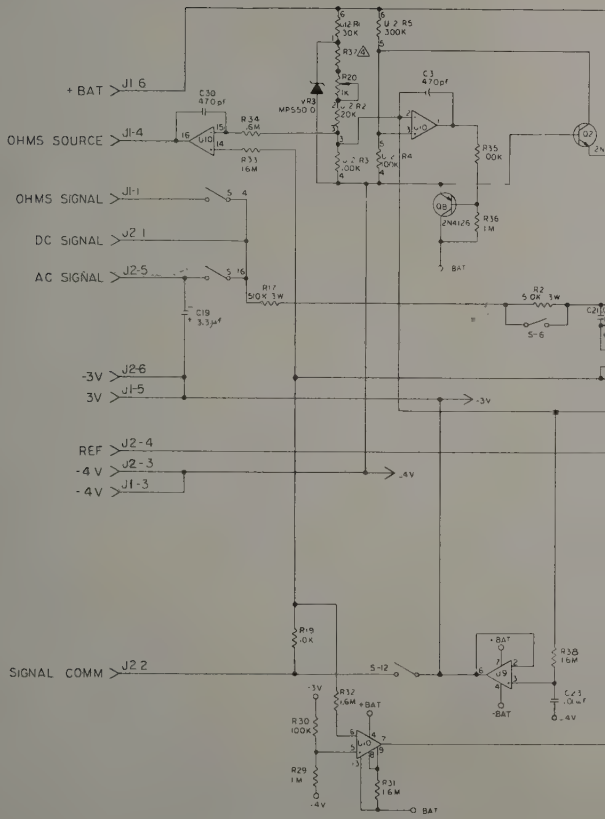


Figure 12. Schematic Wiring Diagram of Input Board


+ BAT
J1 6
OHMS SOURCE
J1-4
OHMS SIGNAL
J1-1
DC SIGNAL
J2 1
AC SIGNAL
J2-5
-3V
J2-6
3V
J1-5
REF
J2-4
-4 V
J2-3
- 4V
J1-3
SIGNAL COMM
J2 2
C30 470 pf
R34 6M
R33 16M
R1 30K
R37
R20 1K
MPS5000
R2 20K
R3 100K
R4 10K
U2 R5 300K
C3 470pf
R35 100K
Q8
2N4126
R36 1M
Q2
BAT
R17 500K 1W
C19 3.3µf
R2 5.0K 1W
S-6
-3V
-4V
S-12
R19 10K
R30 100K
R29 1M
R32 16M
R31 16M
+BAT
-BAT
R38 16M
C23 .10µf
-4V
BAT

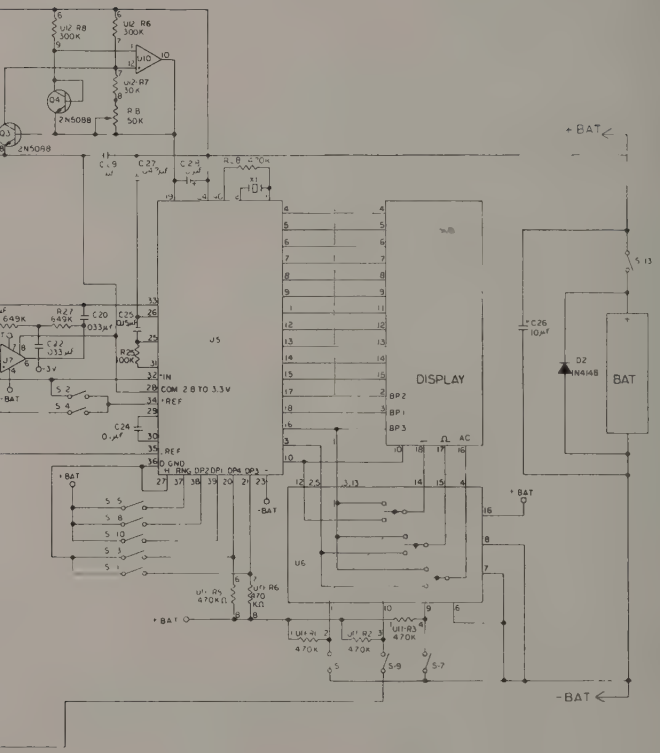


Figure 13. Schematic Wiring Diagram of Display Board

6.4.1 REPLACEMENT PARTS

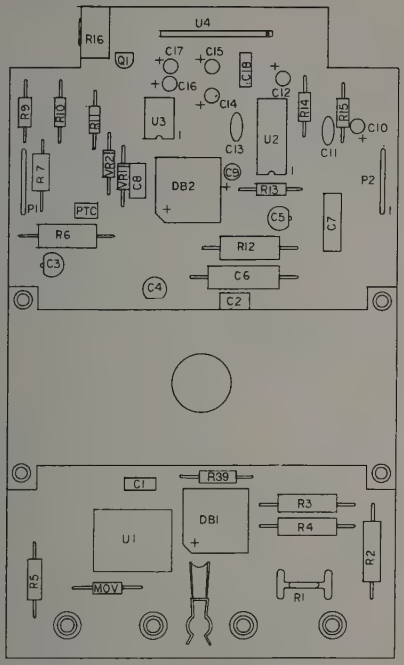


Figure 14. Components Locator for Input Board

Parts List for Input Board

Item No.	Ref. Des.	Part No.	Description	Qty.
1		FG3000-520-117 OR FG3000-510-136	PCB Assembly Input Board 4410 (520-117) PCB Assembly Input Board 4410 (510-136)	1

Parts List for Input Board (Cont)

Item No.	Ref. Des.	Part No.	Description	Qty.
2	3 & 4	FG3000-980-125	Fuse Cup Assembly 370-231 and 370-232	
3		FG3000-420-100	Switch Block	1
4	P1, P2	FG3000-370-236	Cable Flat 6 Pin	2
5	U1	FG3000-310-106	Precision Voltage Divider (SIP) used only with PCB FG3000-510-117	1
		OR		
		FG3000-310-115	Precision Voltage Divider (SIP) used only with PCB FG3000-510-136	1
6	U4	FG3000-300-110	SP 10 Pin	1
7	U2	FG3000-270-101	RMS Converter	1
8	U3	FG3000-270-111	ICL 7660 CPA Volt Conv.	1
9	VR1, 2	FG3000-231-101	Diode Zener	2
10	DB1, 2	FG3000-211-100	Diode Bridge 2A	2
11	C3, 4, 5	FG3000-190-103	Cap. trim bottom adjust	3
12	C9, 14, 15, 16	FG3000-151-101	Cap. 10 μF TAN	4
13	C10, 12, 17	FG3000-151-102	Cap. 47 μF TAN	3
14	C6	FG3000-131-107	Cap. .047 μF 400V	1
15	C7	FG3000-130-100	Cap. .047 μF MYL	1
16	C8	FG3000-130-109	Cap. .0033 μF MYL	1
17	C2	FG3000-130-121	Cap. 0.0082 μF MYL	1
18	C18	FG3000-120-100	Cap. 470 PF DIP	2
19	C11	FG3000-101-101	Cap. 33 PF Cer.	1
20	C13	FG3000-101-103	Cap. 220 PF Cer.	1
21	R16	FG3000-90-107	Pot 500Ω	1
22	PTC	FG3000-84-103	Res PTC 750Ω prepped	1
23	MOV	FG3000-81-102	Varistor 1720V	1
24	R3	FG3000-71-101	Res. .9Ω WW	1
25	R2	FG3000-71-104	Res. .0898Ω WW	1
26	R4	FG3000-51-106	Res. 9Ω .5W M.F.	1
27	R6, R12	FG3000-52-101	Res. 200 KΩ, 3W M.FLM	2
28	R1	FG3000-40-101	Res. .01Ω Shunt (10 amp)	1
29	R7	FG3000-31-151	Res. 150Ω, .5W C. Comp.	1
30	R5	FG3000-31-241	Res. 240Ω, .5W C. Comp.	1

Parts List for Input Board (Cont)

Item No.	Ref. Des.	Part No.	Description	Qty.
31	R14	FG3000-1-120	Res. 12Ω, .25W C. Comp.	1
32	R13	FG3000-1-435	Res. 4.3 MΩ, .25W C. Comp.	1
33	R11	FG3000-1-104	Res. 100 KΩ, .25W C. Comp.	1
34	R9, 10, 15	FG3000-1-474	Res. 470 KΩ, .25W C. Comp.	1
35	Q1	FG3000-251-100	Trans. PNP 2N4126	1
36		FG3000-450-180	Attenuator Hold-Down used only with PCB FG3000-510-117	1
37	C1	FG3000-120-100	Cap. 470 PF DIP for use with PCB FG3000-510-117	
		OR		
		FG3000-120-102	Cap. 330 PF DIP for use with PCB FG3000-510-136	
38	R39	FG3000-51-596	Res. 898 Ω .125 W M.F.	

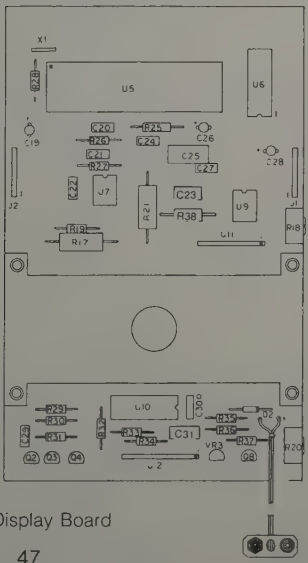


Figure 15. Components Locator for Display Board

Parts List for Display Board

Item No.	Ref. Des.	Part No.	Description	Qty.
1		FG3000-520-119	PC Board Display Assembly-4410	1
2		FG3000-420-100	Switch Block	1
3		FG3000-370-187	Battery Snap	1
4		FG3000-450-118	Cable Tie	1
5	J1, 2	FG3000-370-237	Conn. 6-Pin Female	2
6	U6	FG3000-270-105	I.C. CD4053	1
7	U5	FG3000-270-110	Ana./Dig. Converter	1
8	U7	FG3000-270-115	IC CMOS Op. Amp.	1
9	U9	FG3000-270-113	IC LF 441CN JFET AMP	1
10	U10	FG3000-270-114	IC MC 14573 CP Quad Amp	1
11	U12	FG3000-300-112	SIP 10 Pin	1
12	U11	FG3000-300-113	SIP 8 Pin	1
13	X1	FG3000-360-105	120 kHz Crystal	1
14	Q8	FG3000-251-100	Trans. PNP 2N4126	1
15	Q2, 3, 4	FG3000-251-101	Trans. NPN 2N5088	3
16	VR3, R37	FG3000-560-117	Ref. Diode & Res. Assy.	1
17	D2	FG3000-201-100	Sm. Signal Diode 1N4148	1
19	C19	FG3000-151-100	Cap. 3.3 UF TAN	1
20	C26, 28	FG3000-151-101	Cap. 10 UF TAN	2
21	C20, 21, 22	FG3000-130-119	Cap. .033 UF 50V	3
22	C24, 29	FG3000-130-111	Cap. 0.1 UF MYL	2
23	C25	FG3000-130-106	Cap. 0.15 UF, 5%	1
24	C30, C31	FG3000-120-100	Cap. 470 PF DIP	2
25	R20	FG3000-90-115	Pot 1K	1
26	R18	FG3000-90-114	Pot 50K	1
27	R25	FG3000-51-122	Res. 100 KΩ, .125W M.F	1
28	R26, 27	FG3000-51-868	Res. 649 KΩ, .125W M.F.	2

Parts List for Display Board (Cont)

Item No	Ref. Des.	Part No.	Description	Qty.
30	R17, 21	FG3000-52-130	Res. 510 KΩ, 3W M.F.	2
31	R30, 35	FG3000-1-104	Res. 100 KΩ, .25W C. Comp.	2
32	R29, 36	FG3000-1-105	Res. 1 MΩ, .25W C. Comp.	2
33	R31, 32, 33, 34, 38	FG3000-1-165	Res. 1.6 MΩ, .25W C. Comp.	5
34	R28	FG3000-1-474	Res. 470 KΩ, .25W C. Comp.	1
35	C27	FG3000-130-118	Cap. .047 μF Mylar	1
36	R19	FG3000-1-103	Res. 10 KΩ, .25W C. Comp.	1
37	C23	FG3000-130-112	Cap. .01 μF	1

NOTE: Items 18 and 29 intentionally deleted.

6.4.2 SERVICE MANUAL

A complete service manual is available from Beckman Industrial Corp., for those users who desire to service their own multimeters. To obtain a copy of this manual, send $15.00* (postage and handling) in the form of a check, money order, or a purchase order made payable to Beckman Industrial Corp. See shipping address in Paragraph 6.1.3.

6.5 MULTIMETER STORAGE

WARNING

If multimeter is to be stored at temperatures above 122°F (50°C), remove the battery.

*Prices are subject to change without notice

Section Seven
ACCESSORIES

This section provides a description of the multimeter accessories that are available from Beckman Industrial Corporation.

7.1 VINYL CARRYING CASE (VC-201)

The vinyl carrying case is constructed of durable, padded vinyl and will accommodate any Beckman Industrial Corp. Hand Held Multimeter Model. The case has room for the multimeter, instruction manual, and the TL-245 Probe Set without adding any unnecessary bulk. The back of the case has a handy belt loop.

7.2 DELUXE CARRYING CASE (DC-205)

Handsome, yet rugged, this case offers maximum protection for any Beckman Industrial Corp. Hand Held Multimeter. Constructed of rigid, leather-grained vinyl, the deluxe case has inside compartments for storing the multimeter, TL-245 Probe Set, and the instruction manual.

7.3 DELUXE CARRYING CASE (DC-207)

Handsome yet rugged, this case offers maximum protection for any Beckman Industrial Corp. Hand Held Multimeter and is designed to permit in-case operation. Constructed of rigid, leather-grained vinyl, the deluxe case has inside compartments for storing the instrument, test lead set, the operator's manual, and an extra compartment for a current clamp or small tools.

7.4 HIGH VOLTAGE PROBE (HV-211-10)

The HV-211 High Voltage Probe extends the DC voltage measurement capability of a Multimeter to 50 kV. This accessory is essential for television and CRT terminal service where second anode voltages must be measured. This probe contains a precision 1000:1 resistor divider that scales high voltages down to a level that the multimeter can handle safely. The high input impedance of the probe minimizes circuit loading and assures accurate measurements.

7.4.1 HV-211-10 HIGH VOLTAGE PROBE SPECIFICATIONS

VOLTAGE RANGE
0 TO ±50 kVDC (NOT VAC)
INPUT RESISTANCE
1000 MΩ
DIVISION RATIO
1000 to 1
ACCURACY
±2% at 25 kV, changes linearly to 8% at 50 kV
MAXIMUM INPUT
±50 kVDC or peak AC

7.4.2 OPERATION WITH HV-211-10 HIGH VOLTAGE PROBE

WARNING

The HV-211 High Voltage Probe is used to measure potentially lethal voltages. Always disconnect power and discharge voltage source before connecting or disconnecting the High Voltage Probe.

When the High Voltage Probe is used, the probe replaces the standard test leads. The probe is connected to the multimeter in the same manner as the TL-245 Probe Set leads, and measurements are made as described in Paragraph 4.3.1 except that, because the probe is a precision 1000:1 divider, the Digital Display readings will be in kilovolts. A measured value of 50 000 volts will therefore read +50.0 with the Function/Range Switch in the 200 DCV position.

7.5 RF PROBE (RF-221-10)

The peak detecting RF-221 RF Probe extends the AC voltage measuring capability of a Multimeter to 200 MHz. The RF Probe provides a DC voltage that is calibrated to equal the RMS value of a sine wave.

7.5.1 RF-221-10 RF PROBE SPECIFICATIONS

FREQUENCY RANGE
2 kHz to 200 MHz
ACCURACY
± (1% input + 50 mV), from 2 kHz to 10 MHz
±1 dB from 10 MHz to 100 MHz
±6 dB from 100 MHz to 200 MHz
MAXIMUM READING
25 VRMS
RESPONSE
Peak sensing, RMS calibrated
INPUT IMPEDANCE
1.5 MΩ in parallel with 7 pF
OVER VOLTAGE PROTECTION
130 VRMS at 60 Hz or 250 VDC

7.5.2 OPERATION WITH RF-221-10 PROBE

The RF-221 RF Probe is connected to the multimeter in the same manner as the TL-245 Probe Set leads. Measurements are made as described in Paragraph 4.3.1. Use appropriate DCV range from 200 mV to 200 V and read voltage signal directly in volts RMS.

7.6 AC CURRENT CLAMP (CT-231)

The CT-231 AC Current Clamp extends the AC current measurement capability of any Multimeter to 150 amperes without breaking the circuit under test. The 1000:1 current transformation allows direct reading in amperes when used with the 200 mA AC current range of the multimeter.

7.6.1 CT-231 AC CURRENT CLAMP SPECIFICATIONS

RANGE
10 to 150A RMS AC
FREQUENCY RANGE
30 Hz to 1 kHz
ACCURACY
±2% (60 Hz)
±3% (50 Hz to 1 kHz)
DIVISION RATIO
1000:1
CIRCUIT-TO-GROUND VOLTAGE
1000 VRMS maximum
MAXIMUM CONDUCTOR SIZE
0.45 inch (11.4 mm)

7.6.2 OPERATION WITH CT-231 AC CURRENT CLAMP

The CT-231 AC Current Clamp is connected to the A and COM Input Connectors of the multimeter in place of the TL-245 Probe Set leads. The jaws of the current clamp are placed around one of the current carrying conductors. With the multimeter in the 200 mA ACA position, current is read directly in amperes.

7.7 AC CURRENT CLAMP (CT-232)

The CT-232 AC Current Clamp extends the AC current measurement capability of any Multimeter to 1000 amperes by use of a 1000:1 current transformer. The clamp-on design permits AC current measurements without breaking the circuit under test.

7.7.1 CT-232 AC CURRENT CLAMP SPECIFICATIONS

RANGE
10 to 1000A RMS AC
FREQUENCY RANGE
30 Hz to 1000 Hz
ACCURACY
±1% (60 Hz)
±2% (30 Hz to 1 kHz)
DIVISION RATIO
1000:1
CIRCUIT-TO-GROUND VOLTAGE
1000 VRMS maximum
MAXIMUM CONDUCTOR SIZE
2.125 inches (54 mm)

7.7.2 OPERATION WITH CT-232 AC CURRENT CLAMP

The CT-232 AC Current Clamp is connected to the A and COM Input Connectors of the multimeter in place of the TL-245 Probe Set leads. The jaws of the current clamp are placed around one of the current carrying conductors. With the multimeter in the 2A ACA position, the displayed value is multiplied by 1000 to obtain measured current in amperes.

7.8 AC CURRENT CLAMP (CT-234A)

The CT-234A AC Current Clamp extends the AC current measurement capability of any Multimeter to 400 amperes without breaking the circuit under test. The 1000:1 current transformer allows direct reading in amperes when used with the 200 mA AC current range of the multimeter.

7.8.1 CT-234A AC CURRENT CLAMP SPECIFICATIONS

RANGE
4 to 400A RMS AC
FREQUENCY RANGE
48 Hz to 1 kHz
ACCURACY
±3% (50 Hz to 1 kHz)
DIVISION RATIO
1000:1
CIRCUIT-TO-GROUND VOLTAGE
1000 VRMS maximum
MAXIMUM CONDUCTOR SIZE
1.375 inches (34.9 mm) diameter or
2.5 inches (63.5 mm) wide

7.8.2 OPERATION WITH CT-234A AC CURRENT CLAMP

The CT-234A AC Current Clamp is connected to the A and COM Input Connectors of the multimeter in place of the TL-245 Probe Set leads. The jaws of the current clamp are placed around one of the current carrying conductors. With the multimeter in the 200 mA ACA position, current is read directly in amperes.

7.9 TEST LEAD ACCESSORY KIT (DL-243)

The specially designed DL-243 Deluxe Test Lead Kit comes in a handy vinyl case. The kit includes alligator clips and banana tips. Both tips will plug into the test lead set provided with the kit.

7.10 DELUXE TEST LEAD ACCESSORY KIT (DL-248)

This specially designed Deluxe Test Lead Kit includes a complete assortment of probe tips for every measurement application. The kit includes the following pairs of tips: alligator clips, banana tips, needle tips, medium-size spring-loaded hooks, and large-size spring-loaded hooks. All items are packaged in a deluxe three-compartment cordura nylon fabric case.

7.11 TEMPERATURE/VOLTAGE CONVERTER (TC-253)

The TC-253 converts K-type thermocouple voltages for use with any DMM. It interfaces between the DMM and any K-type thermocouple or any probe using a standard K-type miniature or subminiature connector. The display reads in degrees C or F, which is switch-selectable.

7.11.1 TEMPERATURE/VOLTAGE CONVERTER SPECIFICATIONS

Accuracy:* 22°C ±3°C Ambient

TEMPERATURE RANGE		ACCURACY
°C	°F	
−50° to −10°	−58° to +14°	1.2% rdg. +2.5°C or 4.5°F
−10° to +200°	+14° to +392°	0.5% rdg. +1.5°C or 2.7°F
+200° to +500°	+392° to +932°	0.7% rdg. +1.5°C or 2.7°F
+500° to +900°	+932° to +1652°	1.4% rdg. +1.5°C or 2.7°F

*For total measurement accuracy, include error due to meter and thermocouple.

7.11.2 OPERATION WITH TC-253 TEMPERATURE/VOLTAGE CONVERTER

1. Plug TC-253 into V·Ω and COM inputs of Multimeter.
2. Plug in Type-K thermocouple connecter at input, switch to °C or °F. Type K Thermocouples; TP-254 (Probe with four foot lead) and TP-255 (four foot leads) are available for use with this accessory.
3. Select 200 MVDC range (if "OL", select 2VDC range) and read display in degrees.

7.12 FUSE PACK (FP-260)

Each pack contains four 2A/600V fuses for the Models 4410 and HD140 Digital Multimeters.

MP MASTER
MA26569